SMF: soft x-ray spectromicroscopy facility for material research

-objective:

an understanding of the nanoscale origin of macroscopic (electrical, magnetic and optical) properties of the matter, and the evolution of the system under relevant conditions

-scope of the proposal:

Combination of the scanning and full field transmission x-ray microscopes (reaching 10nm performance) and the photoelectron and photon inelastic emission SR microscope (~5meV spectral resolution) as a tool for break thru study in complex materials, nano electronics, process of self assembly and energy storage

-proponent group:

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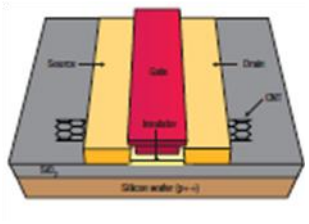
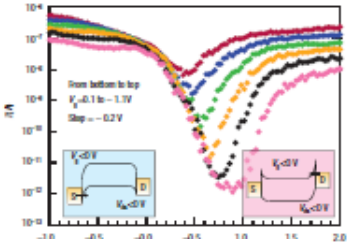
workshop/ meeting on May 20/10

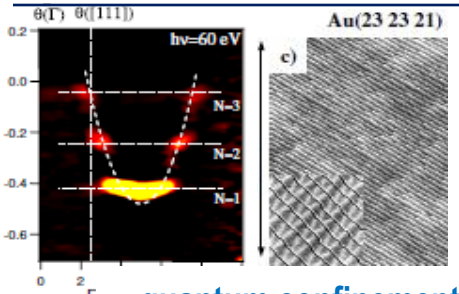
nES: nEw Science

two branches with complimentary scientific mission:





- "at operando" condition
- role of interface formation
- inhomogeneous (polycrystalline) compounds
- distribution of electrostatic potential
- direct measurements of "electron conductivity

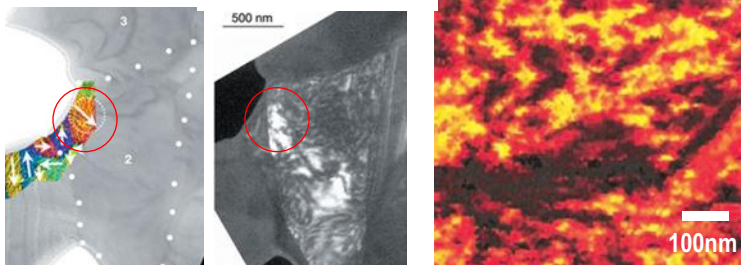


•novel materials and functional devices:

•quantum confinement

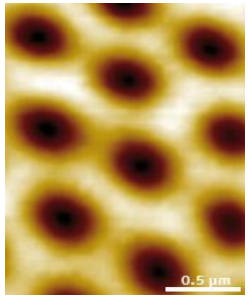
magnetic order

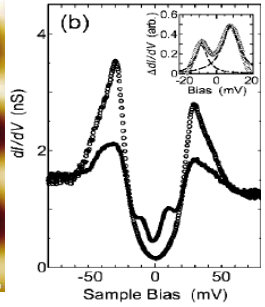
charge order: lattice reconstruction



metal insulator

- competing crystallographic phases
- near Fermi-level electrons: correlations and interactions
- electron driven transition
- charge, spin, orbital ordering

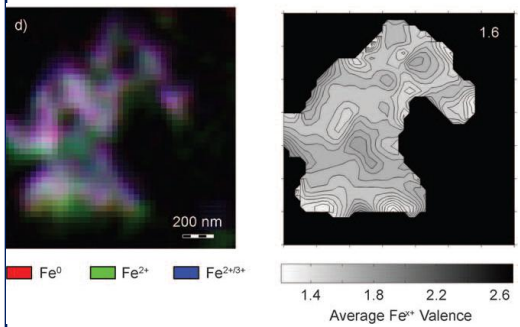




•strong correlation materials: competing phases

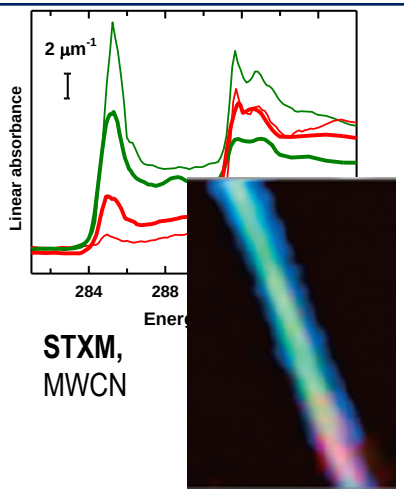
•superconductivity: vortex formation

STXM (transmission, NEXAFS)



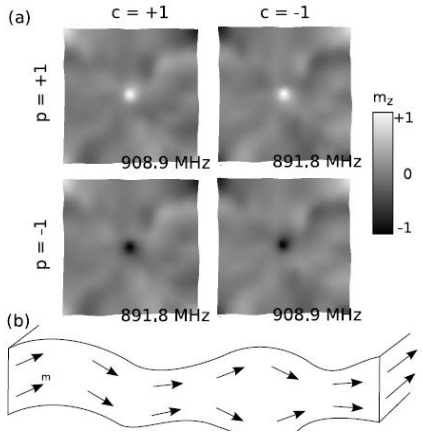
Chemical component images of the catalyst particle, showing the spatial distribution of the different iron species at 450C.

- use light polarization for observing relevant features as small as 15nm on the surface and in the bulk simultaneously
- at relevant conditions



STXM, MWCN

STXM, vortex



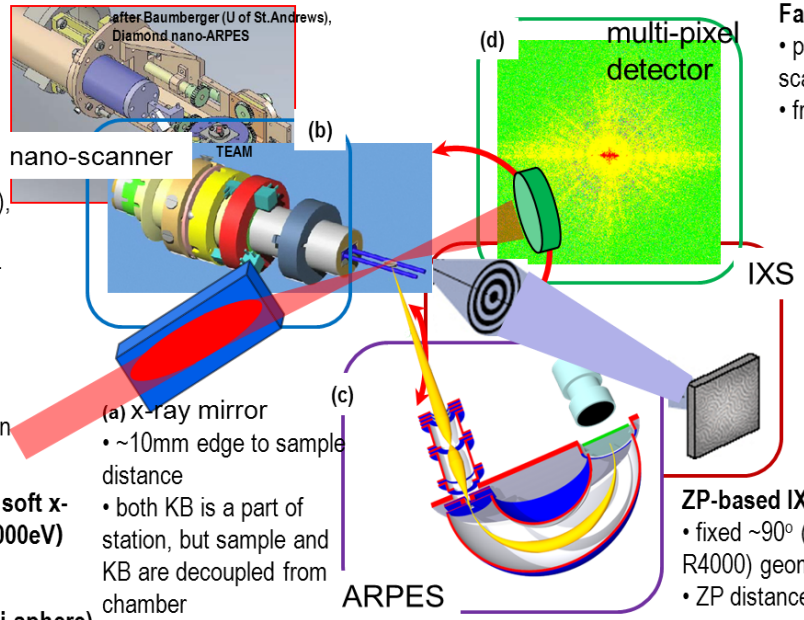
•catalysis and the material for energy storage

•magnetic phenomena

Experimental Technique: nano-ARPES/RIXS

SR spectroscopy at its best

Sample environment
• cryostat – top off-centerd, sample bottom thru T bridge, sample load form the back
• cryo-stages, three angles+scanner plus along the beam translation (?warm), interferometer
• Temperature: LHeT (~25K)->600C
• UHV (<10^{-9}torr)
• *m* shielding
• ?complimentary techniques ?crystal (cleavage) orientation
• preparation chamber



high resolution soft x-ray mono (40-1000eV)

Fast (ALS) CCD
• ptycography and scattering
• frame rate 200Hz,

(a) x-ray mirror
• ~10mm edge to sample distance
• both KB is a part of station, but sample and KB are decoupled from chamber

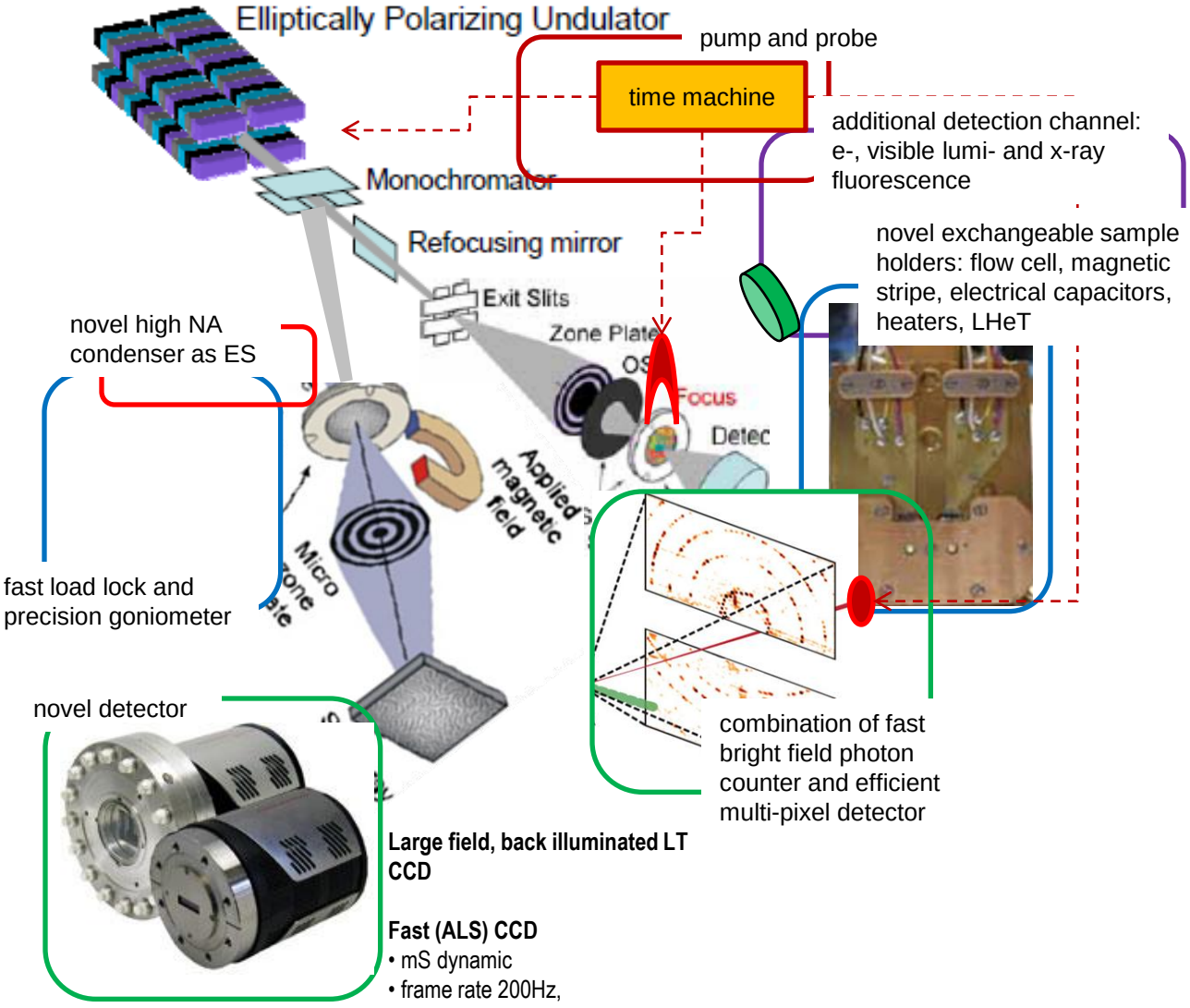
ZP-based IXS spectrometer
• fixed ~90° (to fit aside from R4000) geometry
• ZP distance ~few mm to 1"

Scienta R4000 (200mm hemi-sphere)
• ?vertical e- dispersion plane, only vertical movement
• Energy resolution: < 1.8 meV FWHM at 2 eV pass energy and 20 eV kinetic energy
• Pass energies: 1, 2, 5, 10, 20, 25, 50, 100 and 200 eV
• Transmission mode lens acceptance: +/- 19 degrees
• Angular modes: ± 3.5°, ± 7°, ± 15°,
• Angular resolution < 0.1 degree from <0.1 mm sample
• Kinetic energy range: 0.5 eV – 1500 eV
• Working distance: 34 mm

* spatially resolved ARPES/ RIXS branch would aid the study of fine structure (~5meV) near Fermi edge band renormalization in nano-compounds and origin of electronic excitation in novel materials
* compliment each other: conductive vs. insulating; below and above E_f,
* a gain associated with ultra high brightness of NSLSII will be further multiplied by
-unprecedented luminosity of ZP-based RIXS spectrometer (NA at least 10^2 higher that of existed design)
-state of the art performance of KB pair (to reach 100nm focus at full flux)
-large angle coverage fast x-ray CCD detector coupled with high on sample flux (10^{11}ph/s/bw) extend detection to ~10nm

Experimental Technique: TXM/ STXM

SR microscopy at its best



* High resolution (~10nm) TXM and STXM ideally suite to study time evolution of complex system at operando conditions
* fast acquisition TXM is ideal for large data set (such as tomography or time evolution sequence) where complimentary channels detected by STXM (e^-, fluorescence) facilitate cross correlation analysis
* total control over x-ray polarization extends chemical speciation map to orientation of molecules or magnetic moment

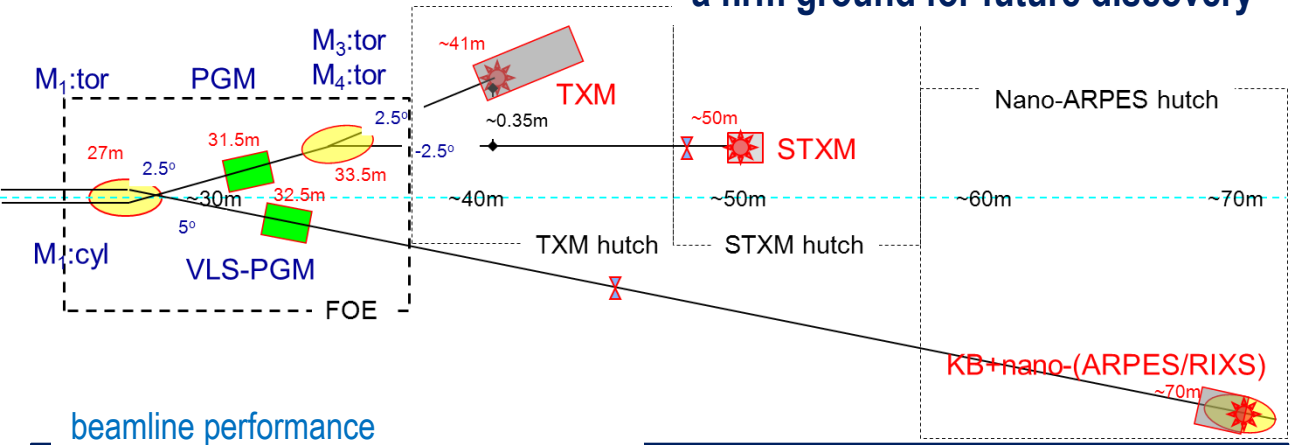
-high flux provided by NSLSII ID is necessary:

-to reach ~10nm performance in TXM with real time acquisition

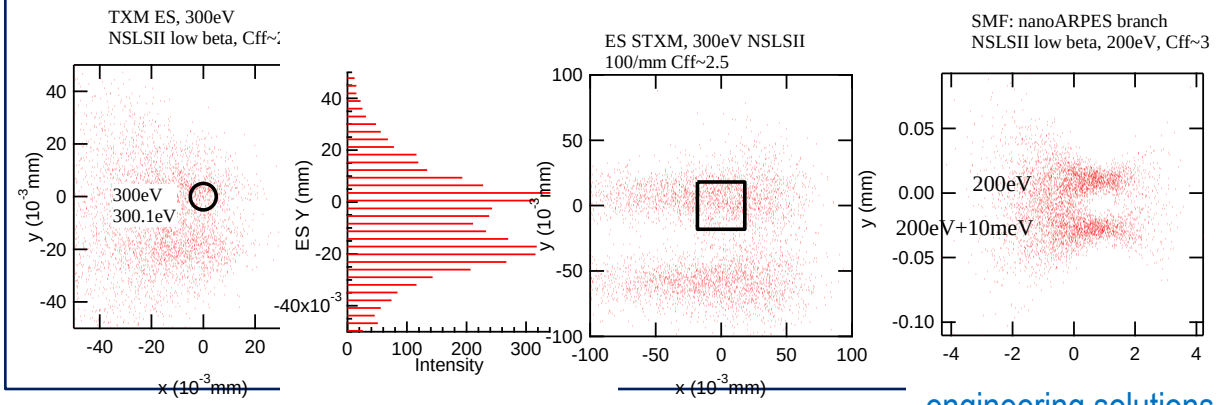
-to increase STXM detection limit at spatial resolution beyond ZP NA

Facility layout

a firm ground for future discovery



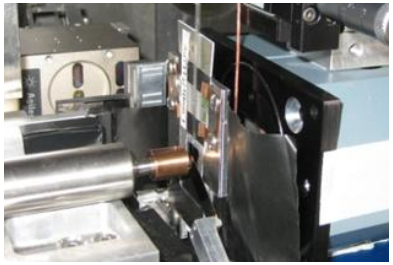
beamline performance

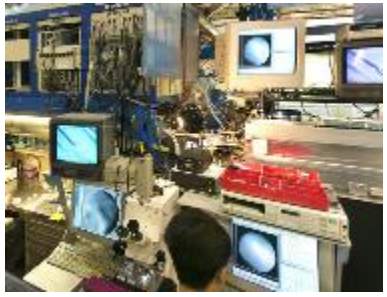


engineering solutions

SM/ REIXS facility at ID10 CLS

ALS-type STXM





CXRO XM-1

* Optical design provides good layout and space sharing between TXM, STXM and ARPES/ RIXS stations
* Independent operation of high (spectroscopy) and moderate (imaging) resolution branches
* Engineering can be firmly based on a combination of existed (ALS-PGM, TXM, STXM) and novel (ZP spectrometer, TXM condenser, cryo-stages) technical solutions. Proponent group has an extended expertise and can confidently guide the project
* The quality of optical components is within the reach